

for flowing water already in use. In the United States, as in this country, the cubic foot is taken as the unit of volume and the second as the unit of time when measuring flowing water in streams, while here the gallon is generally adopted as the unit when dealing with supplies for domestic purposes. In the United States the million gallons in twenty-four hours appears to be recognised as a standard for city water supply, and an acre in area covered one inch or a foot deep in a month or a year is used for irrigation purposes. The unit of inches of rainfall per acre on the catchment area and the resulting run off in gallons for town supplies, or in cubic feet for drainage, is a measure of very general adoption. In India many irrigation engineers have adopted the term "cusecs" as representing cubic feet per second.

With regard to the proportion of rainfall that finds its way into a stream, the author deprecates the use of averages, and expresses the opinion that safe deductions can only be obtained from using the minimum rainfall and taking into account the longest period such minimums may be expected to occupy. The records of the United States show that this minimum period may be expected frequently to last more than three years.

In this country the general rule is to take the average of the longest period over which the rainfall records of the district extend, from this to deduct one-fifth to allow for the mean annual rainfall of the three consecutive driest years, and from the product further to deduct from eleven to fifteen inches for loss by evaporation, soakage, &c., according to the character of the ground, the remainder giving the quantity available for storing. If compensation water has to be provided, a further deduction of one-third of the available supply has to be made. Fourteen inches is commonly taken as the figure representing evaporation, &c., in this country. For example, with an average annual rainfall of thirty inches, ten inches would be available for run off or storage, or, where compensation water has to be given, 6.67 inches would be available for storage. Taking an inch of rainfall as 3630 cubic feet per acre, 10 inches would give 36,300 cubic feet or 226,300 gallons to the acre of gathering ground.

As a general statement, Mr. Rafter's investigations have led him to the conclusion that the minimum rainfall varies from half to one-fourth the maximum.

The late Mr. Symons's proportion for this country was that the rainfall for the wettest year was half as much more than the mean, and for the driest year one-third less, or, taking the average of three wettest years, one-fifth less than this average.

Mr. Rafter considers that averages derived from a shorter period than thirty-five years are not to be relied on within 2 per cent. The same conclusion was arrived at by Mr. H. R. Binnie in his paper on the average annual rainfall reported in the minutes of proceedings of the Institution of Civil Engineers, 1892. This figure was derived from an examination of rainfall statistics from 153 stations situated all over the world. While short periods like five years' average gave an error of 32 per cent., and thirty years 5.8 per cent., the error for thirty-five year periods was only $2\frac{1}{2}$ per cent., and fifty years came no closer.

Although the annual quantity of rainfall varies very much in different localities and in different countries, the same law universally applies as to the relation of the wettest and driest years to the average fall if taken over a sufficiently long period.

As pointed out by the author of the report, caution is necessary in taking the average of the rainfall as a guide; for storage purposes, where the water has to

be collected in a reservoir a minimum fall derived from an average of years may be a trustworthy guide, but where provision has to be made for carrying off the water in artificial channels for drainage purposes, or where the water has to be pumped, as in low-lying districts, the data to be ascertained is the maximum rainfall that has to be dealt with in a short period. Thus, while the rainfall of the year, or even of the winter months, may not have been excessive, yet floods may have ensued due to heavy rain falling for a few days on ground already saturated. In the Fen districts on the east coast of England, which depend entirely on artificial drainage, the rule is to allow for a discharge equal to a continuous fall of a quarter of an inch of rain during twenty-four hours. The mean daily fall of the rain which caused the twenty-one floods in the Witham district since 1852 was an average of 0.26 inch spread over seventeen days; the average annual fall of the district for the wet period was 32.39 inches, and over a period of seventy years 22.93 inches. The greatest fall during this period averaged 0.41 inch spread over fourteen days, in November, 1885, and also in October, 1883, when there was considerable flooding.¹

The figures given in this paper show that in the eastern States of America with a maximum rainfall of from 20 to 60 inches half the rainfall runs off, and that with a minimum fall from a fourth to a sixth. In the western States, with a fall of about 12 inches, the run off varies from half an inch to an inch.

The total run off of a stream depends very largely on the run off of the storage period. Usually about 0.75 to 0.85 of the total rainfall of this period runs off in the stream, while for the summer, or growing period, not more than about 0.1 of the rainfall appears, this small quantity being due to evaporation and absorption by vegetation. The total run off for the year depends very largely on whether or not the rainfall from December to May is large or small. Whether any given stream is low during the summer months or has then a well sustained flow will depend very largely on the rainfall of the month of May. When the May rainfall is heavy enough to produce full ground water, the flow is likely to be well sustained.

The extent of afforestation seems to have a considerable effect on the run off of streams, catchments with dense forests showing a larger run off for the same rainfall than those which are deforested.

THE ARAPAHO SUN DANCE.²

THE scientific value of the anthropological series of the *Publications* of the Field Columbian Museum, Chicago, has been sustained by the important memoir on the Arapaho sun dance by Dr. G. A. Dorsey, the energetic curator of the Department of Anthropology. Although only very recently published, the work bears the date of June, 1903, which will cause superfluous trouble to bibliographers. Dr. Dorsey witnessed the sun dance in 1901 and 1902, and he has taken great pains to give a clear and minute account of this eight-day ceremony. The description is illustrated with a great wealth of illustrations, there being no fewer than 135 plates, many of which contain two figures; it is probably safe to say that no ceremony has hitherto been so amply illustrated. It is also a matter of congratulation that the description is so detailed, as the significance of a ceremony can only be adequately realised when all the details of the events

¹ "The Fens of South Lincolnshire" (Simpkin, Marshall and Co., Ltd.)
² "The Drainage of Fens and Lowlands" (Spon, Ltd.).

² "The Arapaho Sun Dance; the Ceremony of the Offerings'-Lodge. By G. A. Dorsey. Field Columbian Museum, Anthropological Series. Vol. iv. (Chicago, U.S.A., June, 1903.)

are carefully recorded. We can heartily congratulate the author and the museum authorities on the publication of this authoritative memoir. More information would, however, be welcome as to the precise part taken by the several social groups of the Arapaho in this national festival, as this is usually an important element in social ritual. Apparently the ceremony may take place at any time, but it is generally during the winter. It is performed in compliance with a vow.

Many ceremonies are performed in connection with a Rabbit-tipi (or tent), which is erected on the first day, and the men who perform the rites are known as Rabbit-men; the origin of the name is due to a myth. On the second day a sweat-lodge is built, not only as a means of bodily purification, but because they want to be cleansed from former sins, evil desires, and to be protected from all kinds of plagues. Next, a bison should be caught and killed; now they have to content



FIG. 1.—The straight-pipe being smoked by the Sun Dance priests and dancers.

themselves with any old buffalo robe that is available, and this skin has to be painted. On the fourth day the centre-pole for the Offerings'-lodge is cut down by two women, and brought into the camp and erected in its midst with great ceremony; as this new lodge is being completed, final rites are held within the Rabbit-tipi. In this very large lodge is the altar, and here dancing takes place, which is at the present day of a simple character. Near midnight of the second and fourth days a remarkable symbolic ceremony takes place between the grandfather and wife of the Lodge-Maker. The former personifies the sun and the latter the moon, and the ceremony brings strength to the people and increase to the tribe. The sixth day is known as "Medicine Day"; the dancers have now fasted for about forty hours, and it is supposed that by this time their minds are in a proper condition to be

susceptible to the influence of the sun, and they are exhorted to be of a reverent frame of mind. The rising sun is greeted with a dance. During this most important day of the series new chiefs are inaugurated and names changed. There is a considerable amount of evidence that in former times unbridled license prevailed throughout the camp on this night, which was taken advantage of by all, as it was considered one of the rites of the ceremony; in more recent years this has been entirely given up, but the occasion is utilised for courting. The seventh day commences and ends with sun dances, and then takes place the ceremony with the symbolic sun-wheel. The dancing is particularly fatiguing, and finally, in the ceremony witnessed by Dr. Dorsey, a great shout was sent up by all, for the ceremony had come to a happy termination without anyone falling by the way and without a mishap. This impressive exhibition of endurance and faith is termed "gambling against the Sun." It expresses on the part of each dancer his earnest prayer and effort to conquer, to survive, and to complete his three days' fast without falling, in spite of the opposition of the intense heat of the sun; to survive means to win benefit. Then follow the bathing and purification of the dancers.

On the last day of the sun dance ceremony there takes place the final dancing out to meet the sun; the method of advancing by degrees outside the lodge is a form of asking the Man-Above and the Grandfather to listen to their prayers; it also typifies the going after something which is good. A shaking of blankets which takes place may be regarded as a purification rite whereby sickness and sorrow are shaken off. The smoking of the straight-pipe (Fig. 1) at this time, on the part of all, which forms the final performance in the ceremony, is to the effect that all might follow a straight road, that all might be protected, and that the families of those who have fasted and taken part in the ceremony might be guarded from harm, inasmuch as they have performed the ceremony according to the orders of the Man-Above.

Before dispersal, parents, often accompanied by their children, enter the Offerings'-lodge, and after praying, tie on to the centre-pole the clothes discarded by their children during the year. One of these prayers is as follows:—"White Man-Above, my Father, here are the clothes of my child. I am going to deposit them. They are no longer good for my child. By doing this I ask you to watch over him from day to day and keep him from temptation. May he grow up to be a man, to understand your teachings which we have just gone through! I hope you will hear our prayer for my child."

A. C. HADDON.

THE UNGULATE MOLAR.¹

IN the course of his attempt to solve the puzzle of the homologies of the cusps in the more complicated types of ungulate molars, the author of this bulky memoir takes the opportunity of directing attention to certain points with regard to mammalian dentition in general, and also comments on the exceeding intricacy and difficulty of several of the problems presented thereby. The solution of one difficulty, he observes, not unfrequently gives rise to a whole crop of fresh problems, and, paradoxical as it may seem, every increase in our knowledge serves only to reveal the depth of our ignorance.

With the enormous amount of variation displayed

¹ "Recherches de Morphologie phylogénétique sur les Molaires supérieures des Ongulés." By F. Ameghino. *An. Mus. Buenos Aires*, ser. 2, vol. iii. Pp. 541, figures.